Diffraction independent estimation of the ultrasound attenuation coefficient

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Background, Motivation and Objective

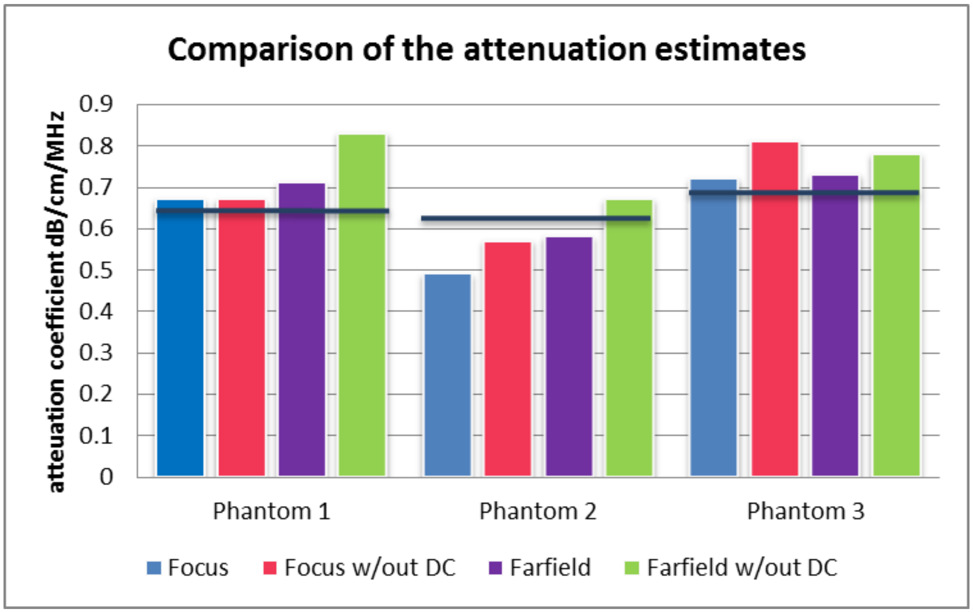
Estimation of the acoustic attenuation (α) has several imaging as well as clinical applications. To obtain an accurate α estimate diffraction effects have to be considered. This is usually done by means of a reference phantom technique which is not practical in the clinical setting. Previously we proposed an iterative attenuation reconstruction technique under the assumption of plane wave propagation. In this method, the local α is estimated by iteratively solving the forward wave propagation problem and matching the simulated signals to measured ones. The aim of the present study was to extend this methodology by including diffraction effects.

Statement of Contribution/Methods

Forward wave propagation was modeled in the frequency domain, applying the effects of attenuation and diffraction. Attenuation was described using a power law, while diffraction was simulated using the angular spectrum approach. Scattering was modeled by propagating the signal received at the scattering site back to the source including the above effects. The parameters of this model can be iteratively changed to approximate the experimentally observed signals. In order to test this methodology, RF signals were recorded from 3 homogeneous tissue-mimicking phantoms (gelatin-graphite; 5.5 cm long; 3.5 cm diameter), the reference α of which were determined using an insertion-substitution method. 20 recordings were made for each phantom when positioned in the focus and in the far field of a single-element ultrasound transducer (5 MHz, focus = 7.5 cm). The proposed method was used to estimate α both with and without diffraction compensation. As an optimization criterion, the sum-of-squared differences between the averaged spectra of the experimentally observed and the simulated signals were calculated using a sliding window of 4 mm with 50% overlap.

Results, Discussion and Conclusion

As expected, when neglecting diffraction effects, α estimates were acceptable near the focal zone of the transducer but were overestimated in the far field (Figure; reference value shown as a horizontal line). Taking diffraction into account reduced the far field estimates bringing them closer to the reference values. These preliminary data show that the proposed methodology might provide an attenuation estimate independent of diffraction effects. A more elaborate evaluation of the proposed method is the topic of ongoing work.



Comparison of the attenuation estimates
atteuation coefficient dB/cm/MHz
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Phantom 1
Phantom 2
Phantom 3
Focus
Focus w/out DC
Farfield
Farfield w/out DC